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US 5472201 A
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INT CL^7 A63B 53/00 53/04 53/06 53/08
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(54) Abstract Title
Ridged Face Golf-Club head

(57) The impact-face 4 of a putter-head 1 has horizontal ridges 6,16 bonded to, or embedded in, an elastomeric substrate 7,17 of lesser hardness than the ridges, resulting in an enlarged impact footprint with enhanced rebound characteristic. The substrate 7 may have regions 8-10 of differing resilience, or the ridges 6 may vary in stiffness along their lengths, to provide greater rebound for off-centre impacts. Ridges 22 may be formed by a thin corrugated shim 20 moulded or bonded to an elastomeric substrate 21 with piercings 24 of the shim to reduce stiffness centrally. A sheet 25 with ridges 26-28 of differing configurations, or wires 33 covered by a moulded layer 32 may also be used for the impact face. Optionally the ridge-elements are of metal, hard polymer or fibre-containing composite material.

Fig.1

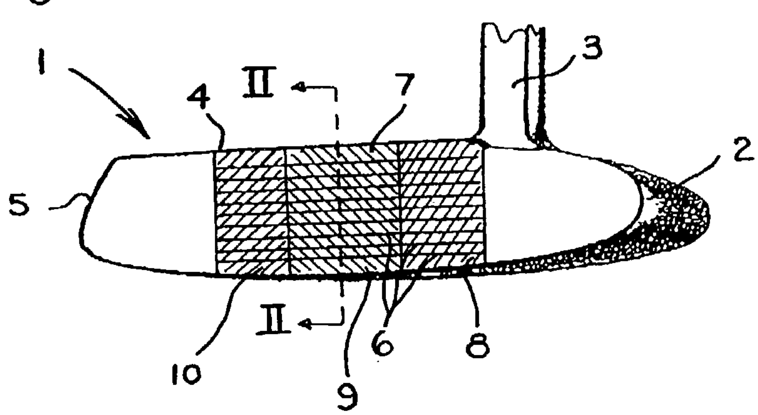

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Fig.1

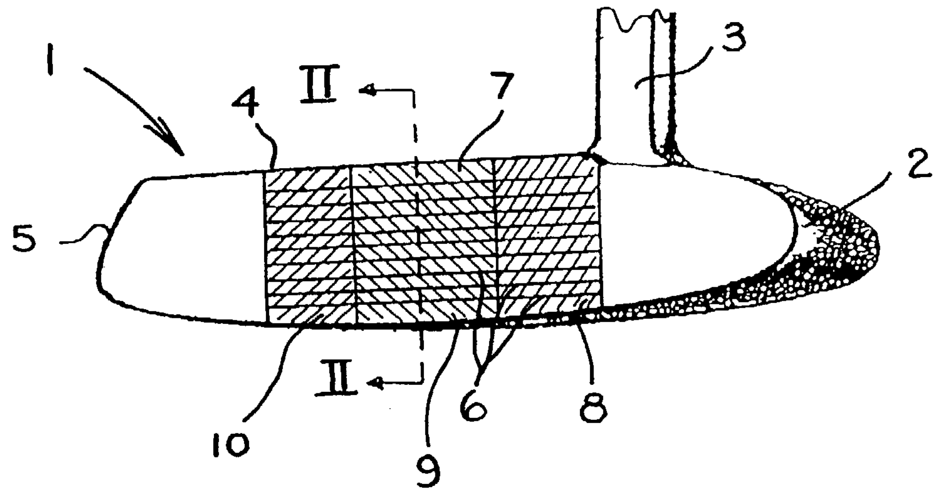


Fig. 2

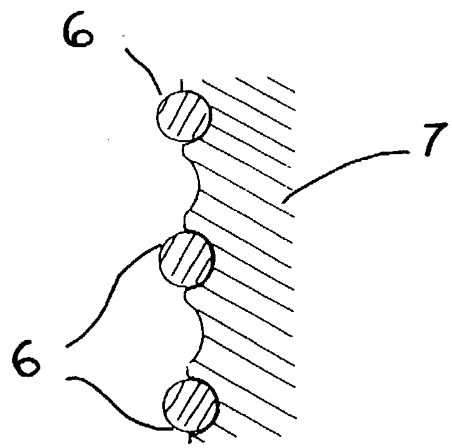


Fig.3

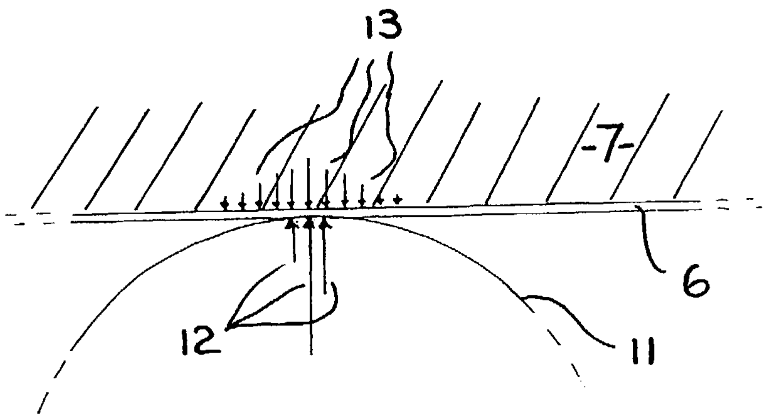


Fig. 4

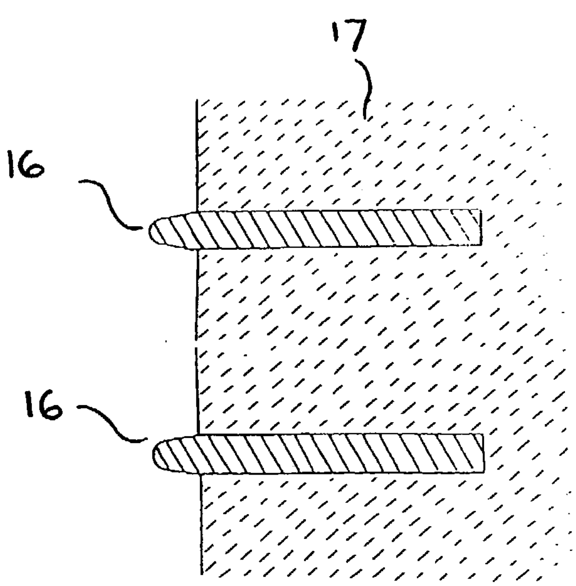


Fig. 5

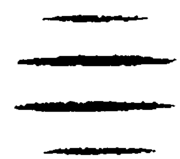


Fig. 6

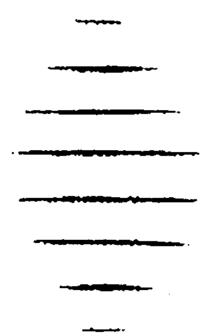


Fig. 7

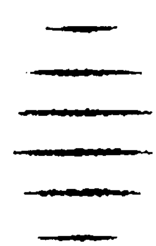


Fig. 8

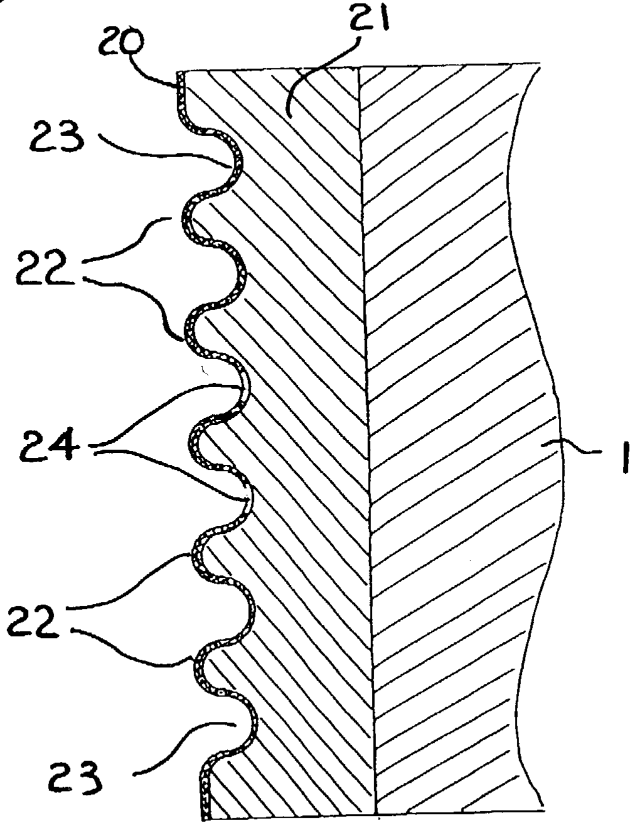


Fig. 9

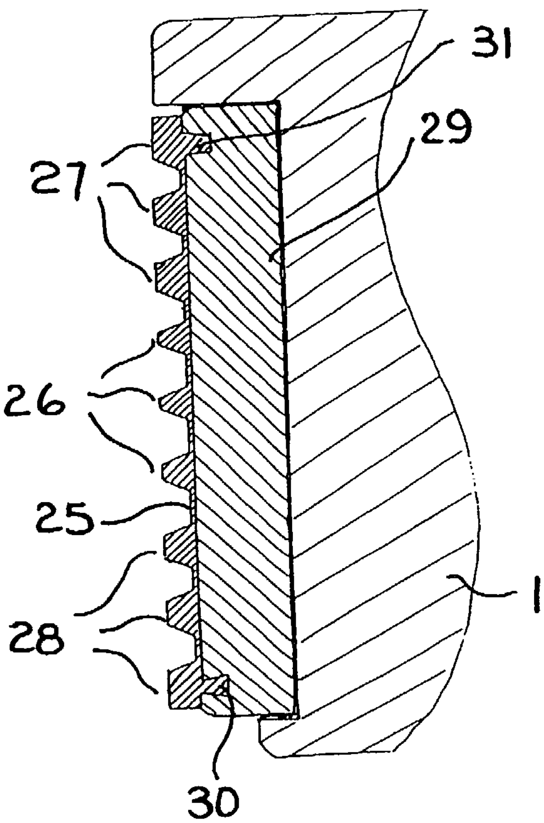
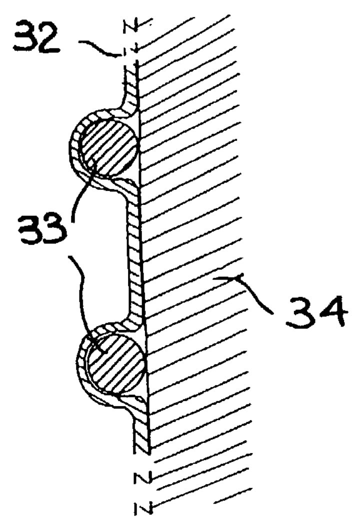


Fig. 10



Golf-Club Heads

This invention relates to golf-club heads and is concerned especially (though not exclusively) with golf-putter heads.

It is known to use a rubber or other elastomeric insert in the impact-face of a putter to reduce noise and vibration at impact with the golf-ball, and give a 'soft feel'. The use of such an insert also enables the rebound properties of the head to be more-readily altered than where a solid metal head is involved. More especially, where the hardness of the elastomeric insert is the same or less than that of the golf-ball cover, a larger footprint or impact-contact area with the ball than normally obtainable with a solid metal head, can be achieved to assist with putting accuracy. However, the use of an elastomeric impact-face of this softness has disadvantages in that it is vulnerable to damage and cannot be machined with the accuracy required to configure the impact-face advantageously for the golfer.

It is an object of the present invention to provide a form of golf-club head that offers improvement over known heads in regard to use of elastomeric material in the impact-face of the club.

According to the present invention there is provided a golf-club head having an impact-face wherein spaced ridge-elements extending substantially horizontal in the face are supported in the head by elastomeric material of lesser hardness than exhibited by the ridge-elements.

The ridge-elements are preferably substantially parallel to one another, but some divergence from parallelism may be useful for purposes of shaping the rebound

characteristics across the impact-face. They are to be harder than a golf-ball cover so as to ensure that deformation at impact creates indentations in the surface of the ball. More especially the hardness of the ridge-elements is desirably at least 75 Durometer D but preferably at least 85 Durometer D.

The substrate material acts to reduce the peak intensity of the impact force and may therefore be of similar hardness or softer than the golf-ball cover. In this regard, the hardness of the substrate elastomer material may be in the range 25 to 90 Durometer A.

The spacing of the ridge-elements (that is to say their pitch) is desirably such as to ensure that at least four ridge-elements contact the ball during, for example, the impact required for a short- to medium-length putt. In this regard, 4.0 millimetre may be regarded as an upper limit for the pitch, but a pitch not greater than 2.5 millimetre is preferred.

The ridge-elements may be substantially rigid, that is to say of very high bending stiffness such that negligible bending occurs during putting impact. However, even in this case they will normally be displaced relative to the club-head during impact with the ball, in consequence of the compliant support by the elastomeric substrate. More especially, the ridge-elements themselves, at least within a central portion of the impact-face, may be compliant and able to bend under normal impact with the ball; such bending is preferably well within the elastic limits of the ridge-elements.

Where the ridge-elements are compliant, their deformation on impact with the ball presses them into the substrate to provide a much larger footprint than otherwise would be the case, distributing the impact force over an

extended area. The bending stiffness of the ridge-elements may be graduated along their lengths or varied from one ridge-element to another to provide increased rebound for off-centre impacts and compensate for loss of impact force that occurs with such impact. The bending stiffness of a ridge-element in the plane normal to the impact-face can be altered by change of shape and/or size of the ridge-element cross-section.

The ridge-elements may comprise a plurality of discrete elongate elements embedded in or backed by the elastomeric material; where the elements are embedded in the elastomeric material, it is preferred that they project from it. Alternatively, they may be integral parts of an elastically-deformable sheet that is corrugated and in face-to-face contact with the substrate. The corrugations decrease the stiffness of the sheet to bending in a plane normal to the lengths of the corrugations, while increasing its stiffness to bending along the corrugation-lengths. The depths of the corrugations may be graduated to provide greater flexibility near the centre of the impact-face and greater stiffness on the perimeter of the impact-face, thereby compensating for impact force variations as a function of impact offset from the centre. The flexibility can also or alternatively be increased by providing narrow slots or other apertures through the sheet.

The elastomer substrate may involve regions (for example, symmetrically with three or five regions) of differing resilience. The region of least resilience may be located centrally of the impact-face, and the region or regions of greatest resilience at the extremes to compensate for loss of impact energy on impact offset. In this configuration, the ridge-elements smooth out the discontinuities between different regions so that the

transition for impacts from one region to the next is gradual with no abrupt changes at the interfaces.

Tests have shown that advantageously the combination of ridge-elements and elastomeric substrate provides increased rebound and reduced acoustic intensity compared with impacts with the substrate alone.

The ridge-elements protect any exposed parts of the substrate surface from abrasion, cutting or tearing, whereas the resilient substrate provides cushioning against hard impacts, which reduces the likelihood of damage to the ridge-elements. Thus, the ridge elements and elastomeric substrate provide mutual protection against damage.

A golf-putter head and modifications thereof all in accordance with the present invention, will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows the putter-head in accordance with the invention;

Figure 2 is a sectional view on the line II-II of Figure 1;

Figure 3 is a schematic diagram showing the instantaneous force distribution on one of a plurality of ridge-elements forming part of the putter-head of Figure 1;

Figure 4 is a sectional view corresponding to Figure 2 of a modified form in accordance with the invention of the putter-head of Figure 1;

Figures 5 to 7 are enlarged views of impact footprints resulting from comparative tests carried out involving the putter-head of Figure 1; and

Figures 8 to 10 are sectional views illustrating respective further modifications in accordance with the invention of the putter-head of Figure 1.

Referring to Figures 1 and 2, the putter-head 1, which is attached at its heel 2 to the putter-shaft (not shown) via a neck 3, has a ridged impact-face 4 located between its heel 2 and toe 5. The ridges of the face 4 are formed by a multiplicity of parallel metal elements 6 that are spaced from one another and extend substantially horizontal on a backing substrate 7 of elastomeric material bonded into the head 1. The substrate 7 is made up of three contiguous regions 8 to 10 of elastomeric material that differ from one another in resilience, and in this respect the resilience of the central region 9 is less than that of the regions 8 and 10.

The elements 6, which are bonded or otherwise secured throughout their lengths within each region 8 to 10 of the substrate 7, are free to flex during their impact with a golf ball so that the substrate 7 is depressed. Depression of the substrate 7 extends along the lengths of the impacting elements 6 outwardly from the impact footprint, that is to say from the area of immediate contact between the putter-head 1 and the ball. The distribution of forces along one of these elements 6 during impact with a ball 11 is illustrated schematically in Figure 3.

Referring to Figure 3, the external impact force on the element 6 due to the ball 11, is typically made up of a small number of localised component forces 12; because the ball-surface is dimpled, contact with it along the

element 6 within the impact footprint will generally not be even and continuous. The resulting reaction on the element 6 within the head 1, which is represented in Figure 3 (and will be referred to below) as composed of small discrete forces 13, is a continuum that has a maximum magnitude behind the centre of impact and decreases gradually towards zero either side of it.

The reactive forces 13 are distributed either side of the centre of impact with effect dependent on the location of it relative to the regions 8 to 10 of differing resilience. If impact occurs at or near the interface between region 9 and one or the other of the regions 8 and 10, the distribution of the reactive forces 13 will vary from one side to the other of the centre of impact. More especially, if the centre of impact is coincident with the interface boundary, the reactive forces will be roughly 50% from one region and 50% from the other, whereas if the centre of impact is slightly to one side or the other of the interface, then that region will contribute a higher proportion of the overall reactive force. If, on the other hand, the centre of impact is located centrally within a region 8 to 10, that region will contribute nearly all the reactive force and little or none will come from the other regions. Thus, the resultant reactive-force that launches the ball from the impact-face 4, changes gradually with shift of the location of the centre of impact from one region 8 to 10 to another, lengthwise of the head 1. This is of advantage in that it provides a smooth transition of head-characteristic and avoids experiencing abrupt changes that would otherwise occur at the interfaces between the substrate-regions 8 to 10, in the absence of the averaging-out effect provided by the ridge-elements 6.

The use of the different impact-substrate regions 8 to 10 in combination with the ridge-elements 6, enables control to be exercised over the variation of ball-launch velocity that accompanies variation in offset of the centre of impact from the sweet spot. By selection of the properties (in particular resilience) of the individual regions 8 to 10, and the stiffness characteristics and pitch (vertical spacing) of the ridge-elements 6, ball-launch velocity as a function of the lateral offset of the centre of impact, can be controlled to be approximately constant over a prescribed range of the offset (for example, over a range of ±25 millimetre). Essentially the same result can be achieved where the substrate 7 of elastomeric material is of uniform elastomeric characteristic throughout (as distinct from comprising regions 8 to 10 of differing resilience) and the elements 6 vary in stiffness lengthwise to provide greater rebound for off-centre impacts in compensation for the launch velocity variation.

The elastomeric materials or material used for the backing substrate 7 are significantly softer than the golf-ball surface so that there is deep deformation at impact and extended distribution of reactive forces along the ridge-elements 6. This allows a small number of impact substrate regions, notably the three regions 8 to 10 in this case, to be used. If the impact substrate materials were harder, a greater number of regions would be required to achieve the same impact correction span. In general, where variation of substrate characteristic is used, an odd number of regions will normally be involved so as to provide symmetry lengthwise of the head 1 about the sweet spot. However, some asymmetry in the impact substrate regions can be advantageous. For example, putter-head asymmetry causes the sweet-spot region to tilt downwardly from heel to toe, and slanting

the interfacing between adjacent regions can be used to rotate the sweet-spot region back into approximate alignment heel to toe (the 'sweet-spot region' can be defined as the area within a locus of points on a putter impact-face where the launch velocity of a standard golf ball is reduced from the centre-impact value by a constant value, for example 2%, at a given constant putt strength). Furthermore, the use of separate substrate regions of differing characteristics makes it possible to provide a putter-head that is custom built (possibly using an even number of substrate regions) to compensate for, or to be otherwise adapted to, an individual player's putting tendencies.

In an alternative embodiment, the central substrate region is provided as an island of material in the centre of the impact-face within one or more surrounding regions of different resilience.

The ridge-elements 6 preferably operate well within their elastic limits with each having a much higher modulus than each, or the, impact-substrate material. In the embodiment of Figures 1 and 2, the elements 6 are straight lengths of steel wire (or a high-tensile alloy wire) having a diameter within the range 0.3 millimetre to 1.5 millimetre or larger, with a pitch chosen to ensure that several ridge-elements 6 come into contact with the ball when the putter is used with impact energies normal to putting. However, other metal wire of circular or flat cross-section, or rod or strip of metal, or high-strength plastics or fibre-containing composite materials, may be used instead, and the elements 6 may be bonded to the surface of the backing substrate 7 partially embedded in it. An example of use of flat elements 16 of strip steel partially embedded in an elastomeric backing substrate 17 is illustrated in Figure 4. Each element 16 is very stiff in the horizontal plane

so very little bending occurs and impact force is distributed uniformly lengthwise of the substrate 17; acoustic attenuation results, but control of rebound does not.

The ridge-elements 6 of the head of Figures 1 and 2 may be held together within a frame to ease assembly in manufacture of the putter-head 1. The frame may be incorporated in the manufactured putter-head 1, each element 6 being held by its two ends to the frame so that it is properly located relative to the other elements 6 and is free to flex elsewhere along it length. In this implementation, the frame itself can provide maximum rebound towards the ends of the ridge-elements 6 and thus form part of the impact-correction mechanism.

Although the force distribution resulting from use of the ridge-elements will also occur to some degree if the elements were embedded wholly within the surface of the backing substrate, it is advantageous for them to protrude from that surface so as to be partially exposed. The ridge-elements, being much harder than the soft backing substrate, are less prone to damage and provide a measure of protection for the substrate where they project from it. The areas of substrate surface exposed between the ridge-elements may be furrowed, as illustrated in Figure 2, or otherwise contoured. The projecting portions of the ridge-elements penetrate the golf-ball cover slightly, at impact. This improves vertical traction and reduces lateral friction, and helps to impart topspin; advantageously it also reduces the effect of swingpath error.

Figure 5 shows a trace of the impact footprint (enlarged by approximately 400%) of a ridge-faced all-metal putter-head with a ball that has a smooth (non-dimpled) surface but is otherwise identical in construction to a standard

balata-covered golf ball. The ridges in this instance, which were very hard and rigid in relation to the ball, were at a pitch of 1.6 millimetre, and the putt strength was controlled to give a ball launch velocity of 2.5 metres per second. The resulting trace is within the compass of a circle having a diameter of 6 millimetre.

Two further impact-footprint traces (again enlarged by approximately 400%) shown in Figures 6 and 7 were obtained with the same ball and putt strength as that used to obtain the trace of Figure 5. However, in these instances putter-heads constructed as described with reference to Figure 1 and 2 were used, the elements 6 being straight lengths of spring-steel wire that were attached at a pitch of 1.6 millimetre to a backing substrate of soft rubber. For the trace of Figure 6, the wire had a diameter of 0.36 millimetre, whereas for the trace of Figure 7 the diameter was 0.68 millimetre.

The footprint trace of Figure 6 is significantly larger than that of Figure 5, and whereas that of Figure 7 is also larger it is not as large as that of Figure 6. The traces of both Figure 6 and Figure 7 are elongate vertically. This is because the portion of the substrate 7 backing the ridge-elements 6 at the centre of impact is depressed and so gives way for the adjacent elements 6 above and below the centre to come into contact with the ball-surface. The elongation of the footprint gives greater vertical traction which can contribute to increased top-spin. A further advantage is that with the impact force distributed over a greater vertical span, the variation of ball launch velocity with the vertical position of the centre of impact on the head, is less pronounced.

It has been found that the rebound and acoustic characteristics of the ridged impact-face 4 of the

putter-head 1 can vary significantly from those of a flat all-metal impact-face. Measurements were obtained with the putter-heads according to Figures 1 and 2, used to provide the traces of Figures 6 and 7, firstly (a) without the metal elements 6 and then (b) with them, and compared with corresponding measurements made using the all-metal putter-head. The comparisons showed that for the same putter-head speed, the launch velocity of a normal, dimpled golf-ball in case (a) was reduced by about 5% as compared with it from the all-metal head. The corresponding reduction of launch velocity for case (b) using ridge-elements 6 having a diameter of 0.36 millimetre was 3%, whereas using ridge-elements 6 having a diameter of 0.68 millimetre it was 0.7%. Such measurements demonstrate that varying the cross-sectional dimension, and in consequence the stiffness, of the ridges allows the rebound characteristic to be varied. From this it is clear that varying the stiffness (for example by changing cross-sectional shape and/or size) of the ridge-elements 6 along their lengths can be used to control the rebound characteristics of the putter-head across the impact-face.

It will be appreciated that different elastomer properties may require different stiffness variation for the ridges. For example, a highly resilient elastomer substrate may exhibit less rebound when combined in a ridge-on-elastomer configuration. In this case, the stiffness of the ridges should be greater rather than less at the centre of the impact-face.

The measurements also show that the acoustic intensity of striking a standard golf-ball with a ridged putter-head according to Figures 1 and 2, is significantly less than that obtained using a flat all-metal head. The ridge-on-elastomer configuration gave in this case a peak transient reduction of -5 dB with much reduced high-

frequency content. Significantly, the plain-elastomer impact-face (case (a) identified above) did not show the same degree of transient reduction, only some -3.7 dB, or the same degree of reduction in high-frequency content. It is believed that the ridge-on-elastomer configuration of Figures 1 and 2 reduces the transient acoustic and vibration energy compared with a plain-elastomer impact-face, by distributing the impact over a much greater area, thereby reducing the peak local force magnitude at the centre of impact.

In the putter-heads of Figures 1 and 2 and Figure 4, ridges are formed in the impact-face 4 by discrete elements 6 and 16, but they may be provided otherwise in accordance with the invention as will now be described with reference to Figures 8 to 10. Figures 8 to 10, show (in section corresponding to that of Figures 2 and 4) constructions of impact-face that may be used as alternatives to those of Figures 2 and 4; in each case the elastomeric substrate may be of unitary or composite form.

Referring to Figure 8, the ridged impact-face in this case is formed by a metal sheet or shim 20 that is directly moulded or otherwise bonded in face-to-face contact with an elastomeric substrate 21 which is bonded into the putter-head. The shim 20 is corrugated to provide projecting ridges 22 separated by furrows 23; only five ridges 22 are shown but typically some ten to fifteen or more would be provided at a pitch of from about 1.5 to 2.5 millimetre. The furrows 23 immediately above and below the centre ridge 22 of the impact-face are pierced with apertures 24 so as to reduce ridge-stiffness. The apertures 24, which may be circular holes or slots, are confined to the central region of the impact-face where the reduction in stiffness is required. Apertures may be provided similarly in the furrows of

other ridges 22, and/or in the flanks or tops of one or more of the ridges 22 to the same effect.

Ridge-stiffness can be varied in other ways. For example, the depth, shape and/or pitch of the corrugations of the shim 20 may be varied.

High-strength polymer or fibre-containing composite materials may be used in substitution for the metal shim and these can be moulded or otherwise formed with varying thickness and shape. Such polymer or composite materials can be readily formed to provide any preferred ridge profile to enhance the contact between ball and putter.

Figure 9 shows an example of the ridge-on-elastomer impact-face of a putter-head in accordance with the invention where the ridges are provided as projecting parts of a single, substantially-planar sheet. The sheet may be extruded, moulded or otherwise fabricated in a polymer, fibre-containing composite material or metal, or a mixture of these materials.

Referring to Figure 9, the ridged impact-face provided by a sheet 25 in this case is of a hard, high-modulus metal or other material, that is formed with central ridges 26 of different configuration and bending stiffness from ridges 27 and 28 above and below them respectively. Also, the average stiffness of the upper ridges 27 may differ from the average stiffness of the lower ridges 28.

The sheet 25, which is of membrane thickness between the ridges 26 to 28, is attached (for example by bonding or moulding) to an elastomeric substrate 29 that is bonded into the putter-head 1. The attachment of the sheet 25 to the substrate 29 is enhanced by means of dovetail and tang anchors 30 and 31 respectively; anchors of these

kinds may be provided, for example, for each ridge 26 to 28.

Where extrusion is used to fabricate the sheet 25, and variation in configuration along the ridges cannot thereby be achieved, stiffness may be varied lengthwise of the putter-head using variation of elastomer characteristics for example in the manner in which variation is provided by the regions 8 to 10 in the head of Figures 1 and 2.

When the central ridges 26 are less stiff than the outer ridges 27 and 28, the rebound characteristic of the impact-face is greater than the rebound characteristic of the elastomeric substrate 29 alone. In other instances (for example where the substrate 29 is of very high resilience), it may be found that the ridges reduce rather than increases the combined rebound characteristic, in which case the stiffness of the ridges should be greater in the centre of the impact-face.

Figure 10 shows a small portion of an impact-face in which a thin outer layer 32 is moulded over metal wires 33 on the surface of an elastomeric substrate 34. The wires 33, which are preferably of spring steel or other low-loss high-modulus spring material, provide the main components of stiffness, the layer 32 aiding the positioning and bonding of the wires to the substrate 34 during fabrication. The layer 32 also provides environmental and physical protection of the substrate 34, and may be of thermoplastic or fibre-reinforced thermoplastic material, vacuum formed. Various fibres, such as of glass, aramid, carbon or hybrid material, may be used to enhance the properties of the layer 32, the main requirement for it being to provide high compliance in the vertical plane normal to the impact-face but stiffness in the horizontal plane. Because the layer 32

is thin, the ridges formed over the wires 33 have a hardness dependent on the wires 33 that is greater than that of the layer 32; in this respect the hardness of the layer 32 can be less than 75 Durometer D.

In the forms of putter-head described above with reference to Figures 8 to 10, various options are available to control stiffness, aid fabrication and enhance ridge-to-elastomer bond strength. Since the elastomer substrate is protected by the shim or the outer ridge layer, very soft elastomer can be used in the substrate and problems of mechanical damage, weathering and ultra-violet degradation are avoided.

The design principles applied to the putter-head as described above are applicable to woods and irons as well as putters.

Claims:

1. A golf-club head having an impact-face wherein spaced ridge-elements extending substantially horizontal in the face are supported in the head by elastomeric material of lesser hardness than exhibited by the ridge-elements.

2. A golf-club head according to Claim 1 wherein the ridge-elements comprise a plurality of discrete elongate elements embedded in the elastomeric material.

3. A golf-club head according to Claim 2 wherein the embedded ridge-elements project from the elastomeric material.

4. A golf-club head according to Claim 1 wherein the ridge-elements comprise a plurality of discrete elongate elements backed by the elastomeric material.

5. A golf-club head according to Claim 4 wherein the elements are bonded to the substrate.

6. A golf-club head according to Claim 4 or Claim 5 wherein the elements are covered by a layer of material bonded to the substrate.

7. A golf-club head according to any one of Claims 1 to 6 wherein the ridge-elements are of flat or circular cross-section.

8. A golf-club head according to any one of Claims 1 to 7 wherein the ridge-elements are of metal, hard polymer or fibre-containing composite material.

9. A golf-club head according to Claim 1 wherein the ridge-elements are integral parts of a sheet attached to the substrate.

10. A golf-club head according to Claim 9 wherein the sheet is a corrugated sheet in face-to-face contact with the substrate.

11. A golf-club head according to Claim 9 wherein the sheet is substantially planar with the ridge-elements projecting therefrom.

12. A golf-club head according to any one of Claims 9 to 11 wherein the sheet is apertured to vary the stiffness applicable to one or more of the ridge-elements.

13. A golf-club head according to Claim 12 wherein the sheet is apertured in a central region of the impact-face.

14. A golf-club head according to any one of Claims 9 to 13 wherein the sheet is of metal, hard polymer or fibre-containing composite material.

15. A golf-club head according to any one Claims 1 to 14 wherein the hardness of the ridge-elements is at least 75 Durometer D.

16. A golf-club head according to Claim 15 wherein the hardness of the ridge-elements is at least 85 Durometer D.

17. A golf-club head according to any one Claims 1 to 14 wherein the ridge-elements have a pitch not greater than 4 millimetre.

18. A golf-club head according to Claim 17 wherein the ridge-elements have a pitch not greater than 2.5 millimetre.

19. A golf-club head according to any one Claims 1 to 18 wherein the hardness of the substrate is substantially within the range 25 to 90 Durometer A.

20. A golf-club head according to any one Claims 1 to 19 wherein the substrate comprises a plurality of contiguous regions of elastomeric material of differing resilience.

21 A golf-club head according to Claim 20 wherein the substrate includes a region of elastomeric material which is located substantially centrally of the impact-face and which is of lower resilience than the elastomeric material contiguous with it.

22. A golf-club head according to any one of Claims 1 to 21 wherein the head is a putter-head.

23. A putter-head substantially as hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.

24. A putter-head according to Claim 23 modified as hereinbefore described with reference to any one of Figures 4 and 8 to 10 of the accompanying drawings.

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Application No: GB 0115484.8
Claims searched: 1-24

Examiner: Mark Sexton
Date of search: 20 December 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.S): A6D
Int Cl (Ed.7): A63B 53/00,04,06,08
Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2249031 A	(TAYLOR MADE GOLF COMPANY) - see whole document, note particularly figures 3-5 and page 5 lines 13-37	1,9-11, 14 & 19
X, E	WO 01/87427 A1	(LINDSAY) - see whole document, note particularly figure 21 & page 29 lines 20-28	1-5, 7,8,15-19, 22 & 24
X	US 5472201	(AIZAWA ET AL.) - see whole document, note particularly figures 2 & 4 and column 3 line 39 - column 4 line 1	1,9-11 & 14
X	US 5467983	(CHEN) - see whole document, note particularly figure 5 and column 2 line 66- column 3 line 24	1,9-11 & 14
X	US 5403007	(CHEN) - see whole document, note particularly figures 1 & 2 and column 2 lines 18-32	1,9-11 & 14

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.